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SOLUTION MANAGMET'S TASK INTEGRATED SYSTEM OF UNMANNED AIRCRAFT IN CONDITIONS OF UNCERTAINITY

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Abstract. *In this article the methods of increase the efficiency of the compensation of indignations of the onboard integrated control systems of Unmanned Aircrafts are considered. On the basis of generalization the disadvantages of inertial and satellite navigation systems it was revealed, that as a result of the insufficient compensation of indignations these systems lose a stable condition. They are exposed to barriers and there is unlimited growth of mistakes in time. For the solution of this actual problem of the onboard integrated control systems a method of increase the efficiency of the compensation of indignations of non-stationary linear systems in the conditions of uncertainty with the observer and with the correction by mistake of recovery was suggested. For this purpose the conditions of uncertainty were mathematically stated, the equations of the onboard integrated control systems were completed, as non-stationary object of management, the observer with correction by mistake of recovery and a matrix of factor of strengthening of the observer are made. As a result the system is asymptotically stable to low-frequency indignations and the accumulation of an error in time at high-frequency indignations is eliminated.*

Keywords: a condition of uncertainty, a matrix of factor of strengthening of the observer, iasymptotical stability, low-frequency and high-frequency indignations, nertial and satellite navigation systems, non-stationary linear systems, onboard integrated control systems, the observer with a correction by mistake of recovery, unmanned aircrafts.

Introduction

Modern Integrated Control Systems (ICS) of navigation and guidance control of Unmanned Aircraft (UA) allow to use modern information technology in the best way. They are characterized by a number of features and by the unification of appropriate functional groups which are very important at a level of technical solutions.

In particular the computing system based on ICS is conjugated to environment by means of arrangements which transform they information needed.

It is necessary to provide the minimal distortions of analog-digital and return transformations which are applied in system of goal definition and in built-in control system of electric characteristics as the technical solution at a level of Analog-Digital Transformer (ADT). Similarly the processor sections of the computing system are identical, no matter what problem they solve: navigation, guidance control or stabilization. The computing system eliminates one of the basic shortcomings of a traditional (compound) onboard control system which is redundancy of the nomenclature of technical scheme solutions. Unification of technical scheme solutions minimizing their nomenclature and the nomenclature of the element base leads to the increase of the system reliability, to the reduction of control and process equipment, to the reduction of lead time and, finally, to the price reduction of the system in general and a process of its design in particular.

Development of UA and need of the problem solution are linked to designation of parameters of objects' movement. Therefore a complex of new requirements on accuracy and safety of information is requested regarding coordinates, speed, and orientation of moving objects.

Conditions of application and operation of UA require advanced accuracy and high frequency of navigation definitions at all stages of their usage, starting from the moment of lighting up onboard systems or takeoff and till the end of operational commitment. Nowadays, in addition to the requirements of accuracy other parameters such as integrity, availability and long term navigation maintenance are on request [1].

An indicator of the integrity is a probability to detect the system operating characteristics (firstly its accuracy) from a required limit and the message about it during the time frame.

Accessibility is defined by probability of reception trustworthy information at present time with required accuracy. The continuity is characterized by the probability of maintenance and by the system of trustworthy information on the set interval of time. In turn, reliability is defined as a capacity of a navigation system to support its characteristics with specified probability in required limits on the certain period of time in any area. Maintenance of a required level of these factors is frequently more difficult problem, than the control of necessary accuracy.

Maintenance of the set levels of accuracy and the specified quality indicators of reliability makes special demands to modern and perspective UA which first of all should be presented by trace inertial (INS) and satellite navigation systems (SNS).

Accuracy is considered to be the aviation standard for SNS precision of civil planes. There are well-known examples of realization more precise systems in which the mistake of coordinate's definition does not exceed several hundred meters in an hour of flight. SNS quickly reaches place in optional structure onboard equipment because of high accuracy which makes 10–15 m Acr. [2]. Operating experience of SNS has shown that having a lot of positive qualities, SNS cannot make all demands according to the qualitative characteristics which are listed above. In the table basic features and minuses of SNS and INS are summarized.

Generalizing minuses both INS and SNS it is possible to approve that the susceptibility to barriers is conditioned by insufficient disturbance-variable compensation.

Therefore INS is not stable to barriers, and SNS with every phenomenon of disturbances keeps stable position, but in such way it forms accumulation of errors. Thus, the disturbance-variable compensation is one of the primary goals of control systems, which is very important for modern UA.

Similarly [3] technical problems are stated as the conditions of uncertainty which are formulated due to incompleteness of the information with regard to the type and parameters of characteristics, in the result of which precise data about the features of object operation are impossible, and also because of physical factors, which are caused by the irregularity of measuring devices and by the errors of operating devices.

Similar problems [4; 5] are solved with the application of optimization methods, taking into account uncertainties which lead to the increase of the efficiency of disturbance-variable compensation.

For the mathematical formulation of a problem let's assume, that the condition of UA is considered to be the disturbed motion of linear, non-stationary control object, which is described by the equation:

$$\dot{X} = A(t)X + B(t)U, \qquad (1)$$

with primary scenarios:

$$X(t_0) = X^{(0)}$$

and the equation of the optimal control, which was received as a result of synthesis:

$$U = C'(t)X \qquad (2)$$

Features and minuses of SNS and INS

Type of system	Main features	Minuses
INS	High accuracy. Mistakes don't have tendency to grow	Low speed of updating information (1–10 Hz). Absence of the information on orientation. Susceptibility to barriers
SNS	High speed of the information delivery (up to 100 Hz). A full set of necessary information for management, including orientation. Full autonomy. No aptitude to external barriers	Unlimited growth of mistakes in time. Necessity of well-known information about the model of a gravitational field

where X=x1 (t), x2 (t), … .xn (t) - n – is a measured vector of variable conditions;

U = u1 (t), u2 (t), … .um (t) - m – is a measured control vector;

A (t) and B (t) are known on the interval [t0, t1] matrixes of functions with the sizes n×n, n×m respectively;

C ’ (t) – is a required matrix with the sizes m×n.

At the uncertainty associated with incompleteness of the information on a condition vector, realization of this management is at a loss, because not all variable conditions of the object are available for measurement, only the components of some r-dimensional vector Y is connected with variables of a condition by a parity (apparently, that r <n):

$$Y = D(t)X \,. \tag{3}$$

Thus, there is a problem of recovery (supervision, an assessment) vector X (t) according to the results of measurement Y (t) on interval [t0 t]. When the vector of a condition is restored it is possible to realize the operation (2), replacing in it the valid condition, restored by the condition vector.

The equation of the regenerator, with the restored variables of condition XB, is written in the form of:

$$\dot{X}_B = A(t)X_B + B(t)U \,, \tag{4}$$

with primary scenarios:

$$X_B(t_0) = X_B^{(0)} .$$

Obviously, if $X_B^{(0)} = X^{(0)}$, so the solution of the equation (4) precisely coincides with the solution of the equation (1). If so, there is an error of restoration. It complies with the equation:

$$\dot{e} = A(t)e(t) \,, \tag{5}$$

Where $e(t_0) = X^{(0)} - X_B^{(0)}$. If the measured variables y (t) …, yr (t), in the regenerator (3) are not used, such equation on the basis of comparison of the measured value vector Y with the restored value $D(t)X_B$ is:

$$\dot{X} = A(t)X_B + K(t)[Y - D(t)X_B] + B(t)U \,, \tag{6}$$

With scenarios $X_B(t_0) = X_B^{(0)}$ in which K (t)-is some matrix with the sizes n×r, is called as a matrix of coefficients and strengthening the observer or the equation of the observer with correction by the error of restoration, and the equation refers to:

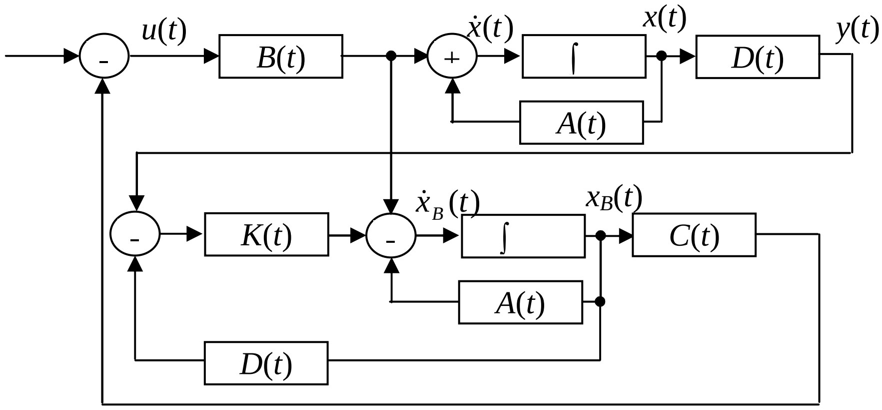
$$\dot{e} = [A(t) - K(t)D(t)e], \tag{7}$$

With scenarios $e(t_0) = X^{(0)} - X_B^{(0)}$ which shows the error of restoration. If there is such matrix K (t), that the observer (6) is asymptotically stable, according to (7) the error of restoration is $e(t) \to 0$ if $t \to \infty$.

Structural diagram of UA system consists of linear, non-stationary ОУ which is described by the equation (1) and where the quantity of variable conditions available to direct measurements and is defined by the equation (3), by the observer (6) and with the optimal control which appropriates the equation (2) is shown on the figure.

Conclusions

Thus, it was revealed, that among technical problems which lead to the reduction of overall performance of UA, constructed on the modern information systems, are those which are connected with incompleteness of the information about ОУ and with physical factors, which are caused by the irregularity of measuring devices and by the errors of operating devices which reduce the compensation of high-frequency disturbances.



Structural diagram of UA with linear non-stationary control object, with optimal control in the conditions of uncertainty (with the observer)

On the example of optimal control system of linear non-stationary object in conditions of uncertainty it was found that with the aim of control realization or for increase the efficiency of disturbance-variable compensation, essential observer with correction by the error of restoration is necessary. In this case the system is asymptotically stable.

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